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Research Article

Choosing the best city of the future

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Abstract

This paper describes various possibilities of the cities of futures considering various constraints and demand of society, environment and geography. The need for future cities arises because of the rapid growth in population and thereby causing a decline in the living standards. In the United States itself, many people are moving to cities every day. Today cities are getting crowded and if the influx continues at the same rate, current cities will become unmanageable and unlivable.

More population means faster consumption of natural resources which eventually leads to ecological imbalance. Already more than 80% of world's forests are gone. The food consumption has also doubled over the last fifty years and this has exerted pressure on the landscape through the use of artificial fertilizers. The use of artificial agents to boost agricultural productivity has significantly marred the flora and fauna leading to loss of a huge amount of bio diversity.

Another problem with the increasing population and population migration to cities is the rise of congestion on the city roads. In the United States a person drives 7500 miles in 1600 h with an a average speed of 4.68 mph. To accommodate the population approximately 2000 trees are cut in a minute in the Amazon alone.

On top of all that, with increasing wealth the average house size has almost doubled since 1970 and this has further caused the decline of arable land and forests. To deal with the problem of rising population and congestion within the cities, we need to plan cities of the future that will be able to utilize the available resources in a more efficient and cleaner manner. The future city project aims to delve into details of various future city models and aims to find out which model will be best suitable depending upon the strategic criteria that we have used to evaluate the various merits of the BOCR model.

The four alternative kinds of cities are analyzed below according to their merits. They are A. Compact City, B. Elevated City, C. Green House City, and D. Water City.

Keywords: BOCR model; Future city; MCDA; AHP

1. The ANP model

The model that we chose to find out the most suitable design for a future city was an ANP Model (Saaty, 2005, 2009). This type of model focuses on one main goal, which of the four cities is the most possible model for a future city, and is then linked to the Benefits, Opportunities, Costs, and Risks of the decision process. Priorities were then inserted, and all data that was appropriate was based on our own opinions and experiences. Below the figure an ANP model is shown that was used for

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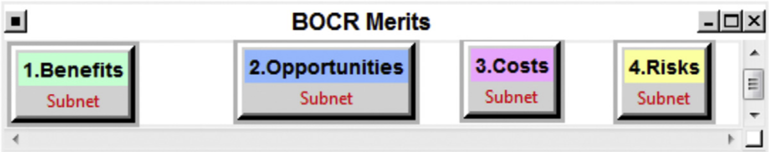
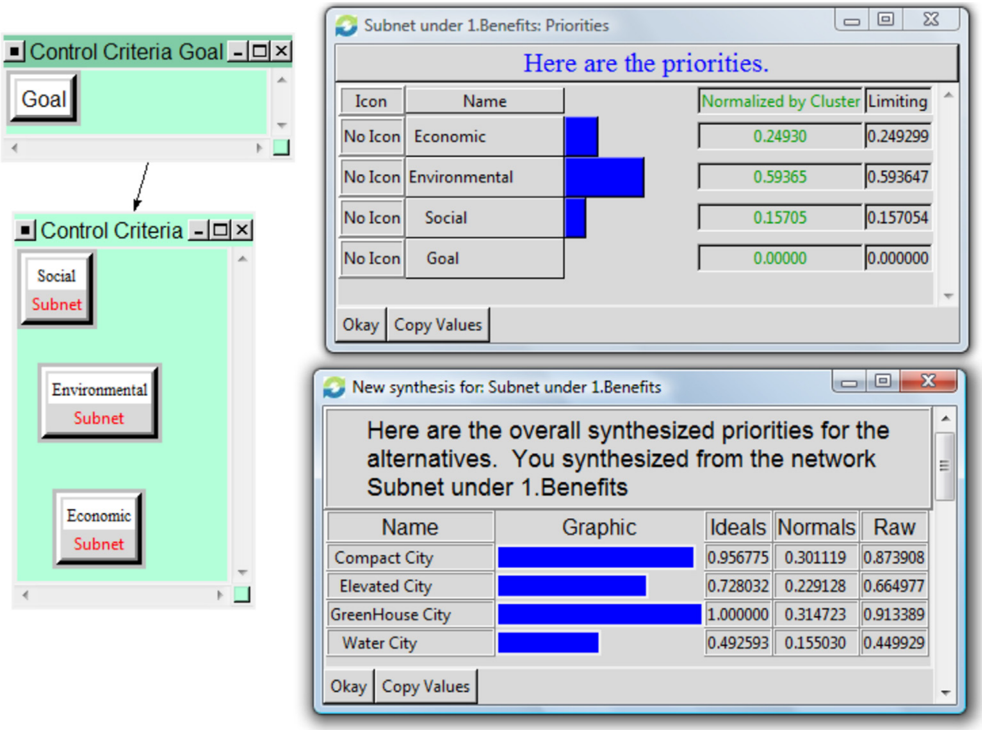
this decision making process. In our model we have not compared the alternatives among themselves as we felt that they do not influence each other mutually.



1.1. Benefits

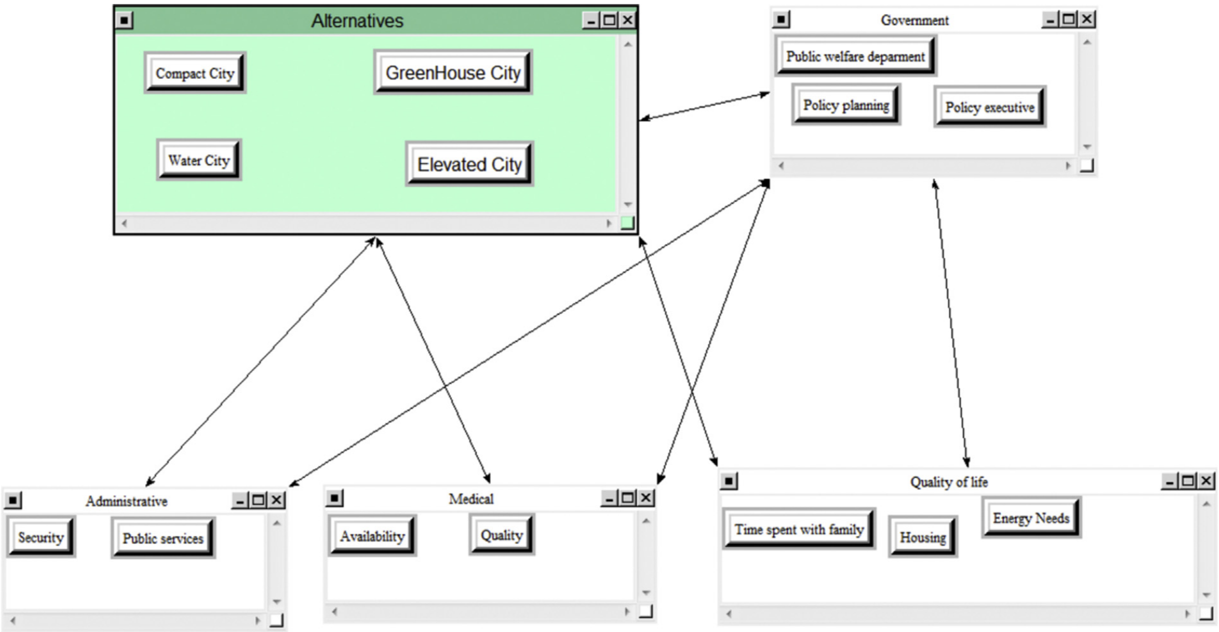
Under the benefit subnet, there are social, environmental and economic benefits as the control criteria for judging the benefits of the alternative cities. The figure below shows the benefits control criteria and the priorities of the control criterion. It also shows the priorities of the alternatives under the benefit merit.



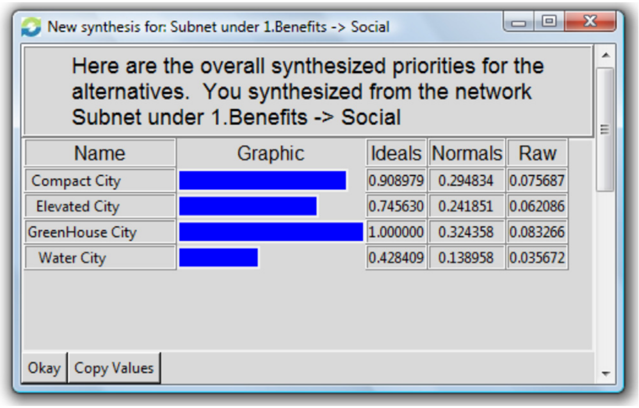
Under each control criterion, there is a subnet which uses comparisons among the various decision-making/influencing entity/parameter and gives a priority order to the alternatives.

1.2. Benefit – social subnet and synthesis

The social subnet measures the benefit of the future city in terms of time spent in traveling, housing needs of the increasing population, availability and quality of medical facilities, the quality of public services available and energy demand of the society for that city. The figure below shows the social subnet for the Benefits.



After Synthesis, the priorities of the alternative cities are as shown in the figure below. Compact City and Green House City are almost equal in priority as far as social benefits are concerned.


New synthesis for: Subnet under 1.Benefits -> Social

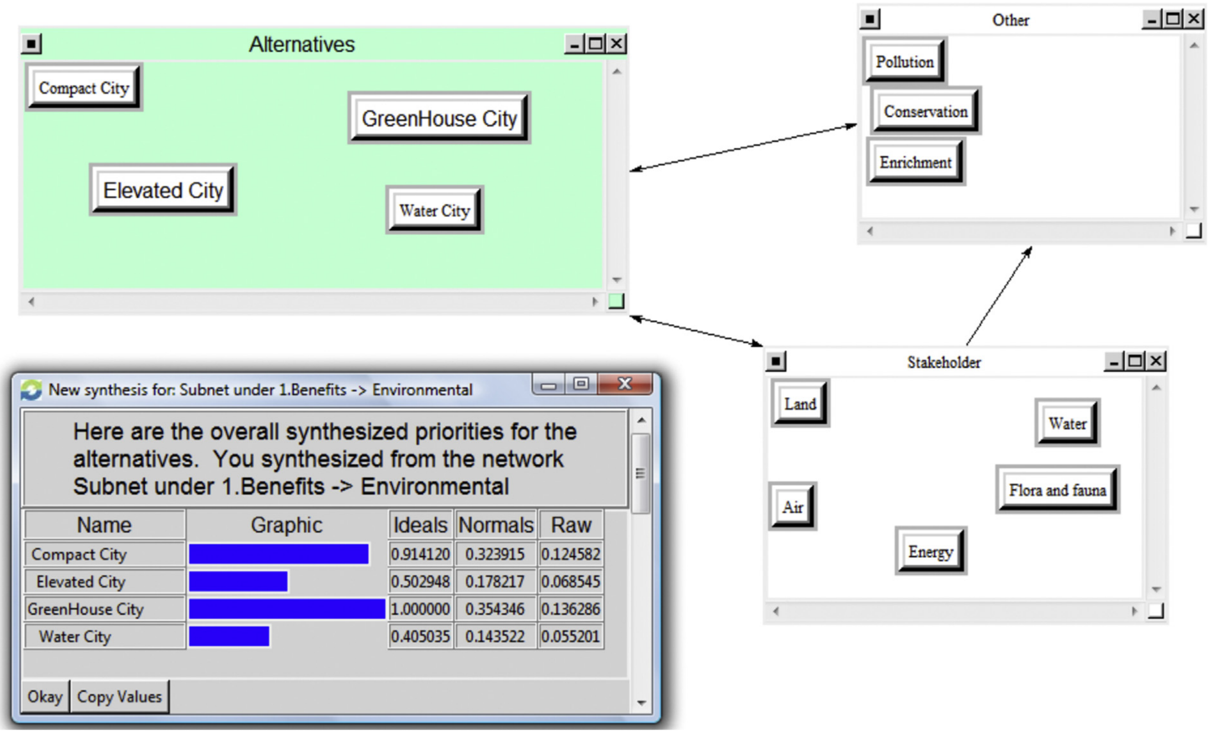
Here are the overall synthesized priorities for the alternatives. You synthesized from the network Subnet under 1.Benefits -> Social

Name	Graphic	Ideals	Normals	Raw
Compact City		0.908979	0.294834	0.075687
Elevated City		0.745630	0.241851	0.062086
GreenHouse City		1.000000	0.324358	0.083266
Water City		0.428409	0.138958	0.035672

Okay Copy Values

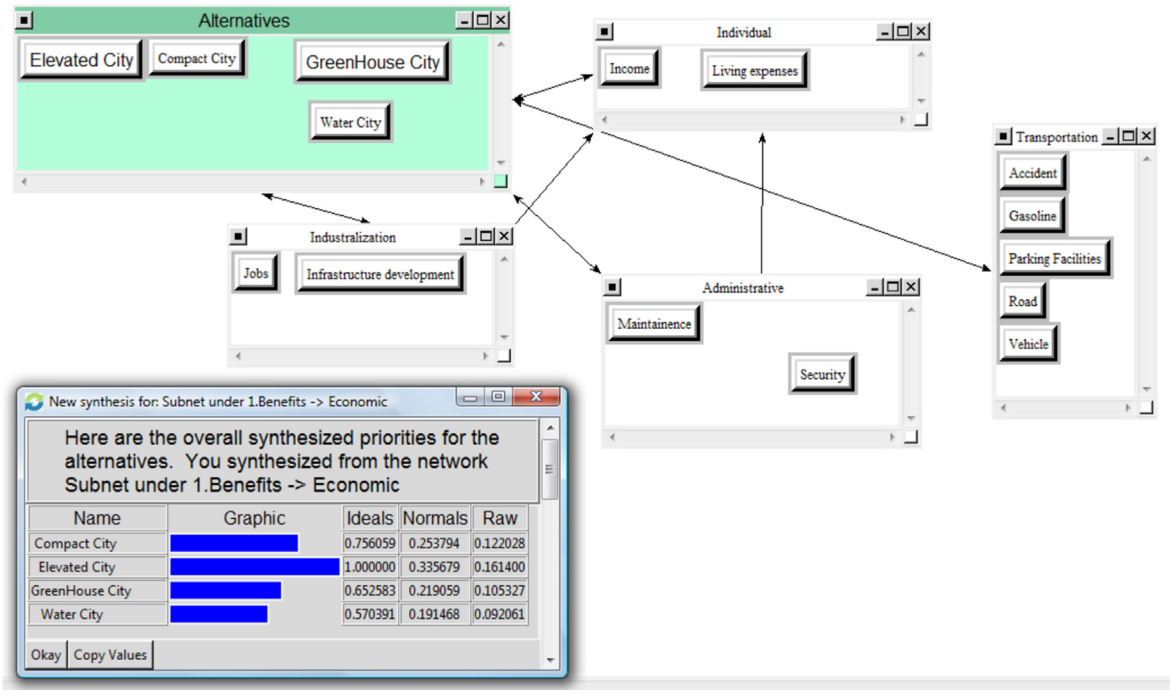
1.3. Benefit – environmental subnet and synthesis

The environmental benefits were measured on parameter such as reduced pollution, pressure on natural resources, energy conservation and the impact on flora and fauna. The figure below shows the environmental subnet. The synthesis of the subnet shows that the Green House City has the highest priority.



1.4. Benefit – economic subnet and synthesis

Economic benefit has been measured on reduced expenses in living, maintenance and development of infrastructure, the cost for parking facility development and transportation. The figure shown below shows the economic subnet and synthesis. Elevated City has the highest priority.



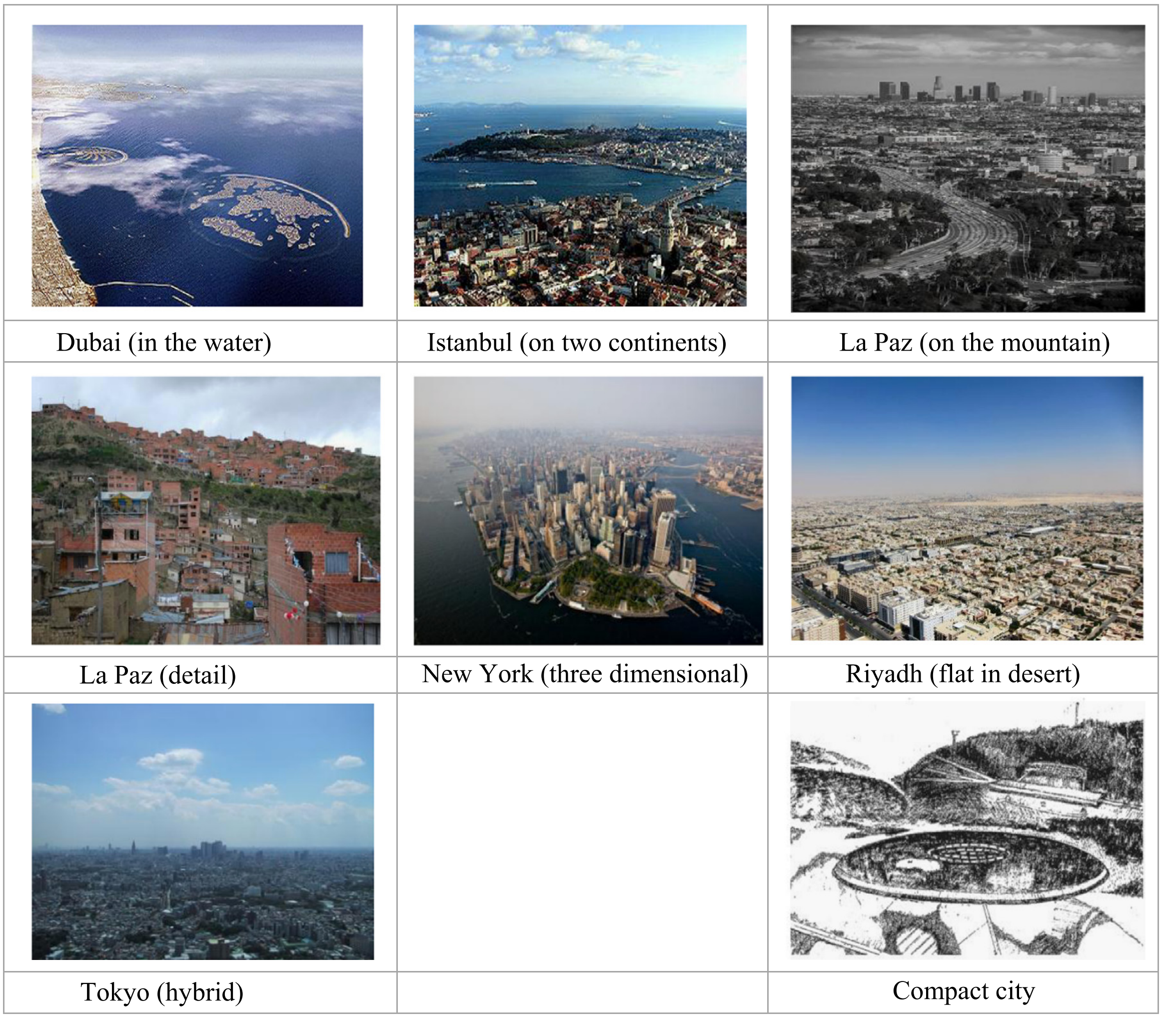


Fig. 1. Different cities of the world.

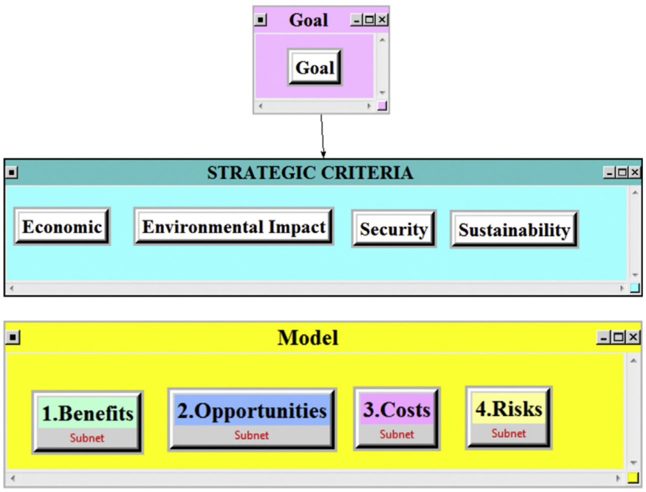
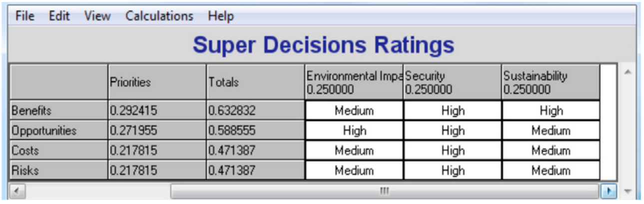


Fig. 2. Main structure of the model.

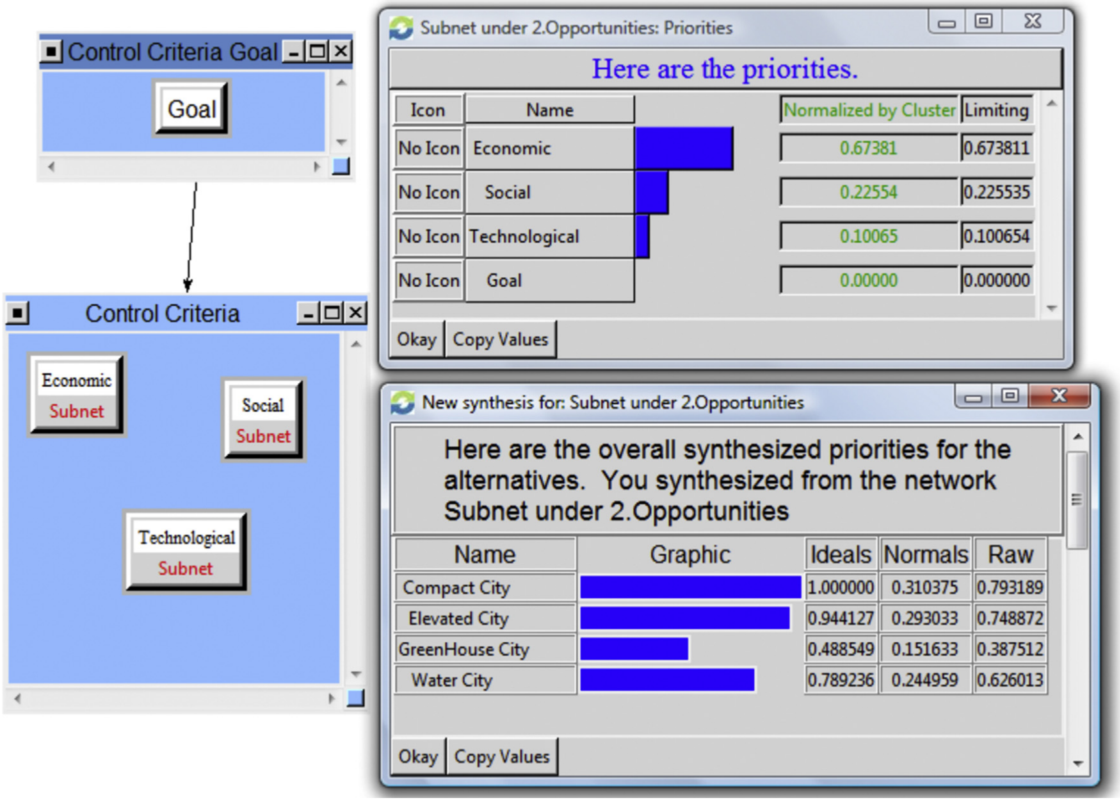


	Priorities	Totals	Environmental Impa 0.250000	Security 0.250000	Sustainability 0.250000
Benefits	0.292415	0.632832	Medium	High	High
Opportunities	0.271955	0.588555	High	High	Medium
Costs	0.217815	0.471387	Medium	High	Medium
Risks	0.217815	0.471387	Medium	High	Medium

Fig. 3. Strategic criteria.

1.5. Opportunities

Under the opportunities subnet, there are economic, technological and social opportunities as the control criteria for judging the benefits of the alternative cities. The figure below shows the opportunities control criteria and their priorities. It also shows the priorities of the alternatives under the opportunities merit.



1.6. Opportunities – economic subnet and synthesis

The economic opportunities have been measured on the parameter criteria such as improving the budget for health and security and the opportunities for job creation for the increasing population. The figure below shows the economic subnet for opportunities and the synthesis for the subnet. Compact City has the highest priority.

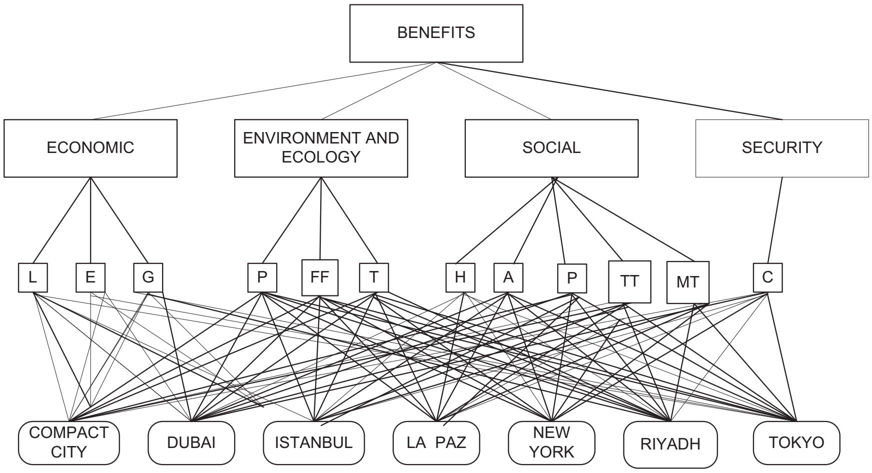


Fig. 4. The best city benefits hierarchy.

Table 1
Criteria under Benefits.

Benefits	
Label	**Criteria**
Economic	
L	Living expenses
E	Energy consumption
G	Per-capita income growth
Environment and ecology	
P	Pollution
FF	Flora and fauna
T	Traffic
Social	
H	Housing
A	Accessibility of health services
P	Public services
TT	Time spent in traveling
MT	Metro areas
Security	
C	Crime rate

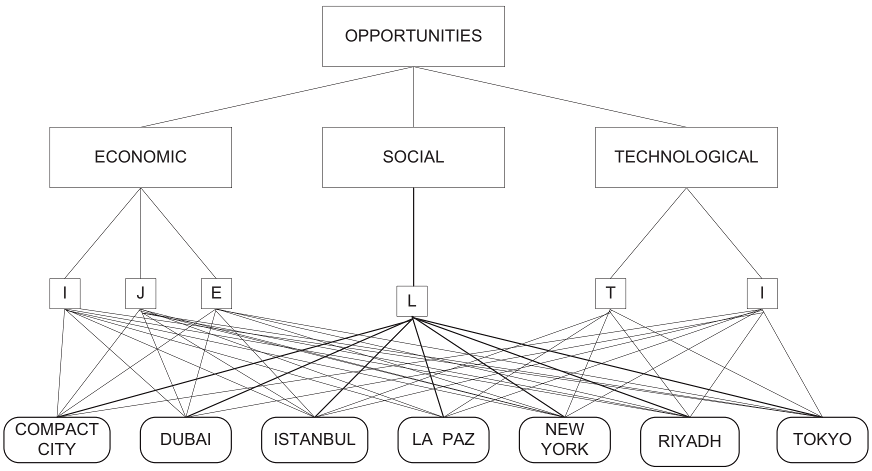


Fig. 5. The best city opportunities hierarchy.

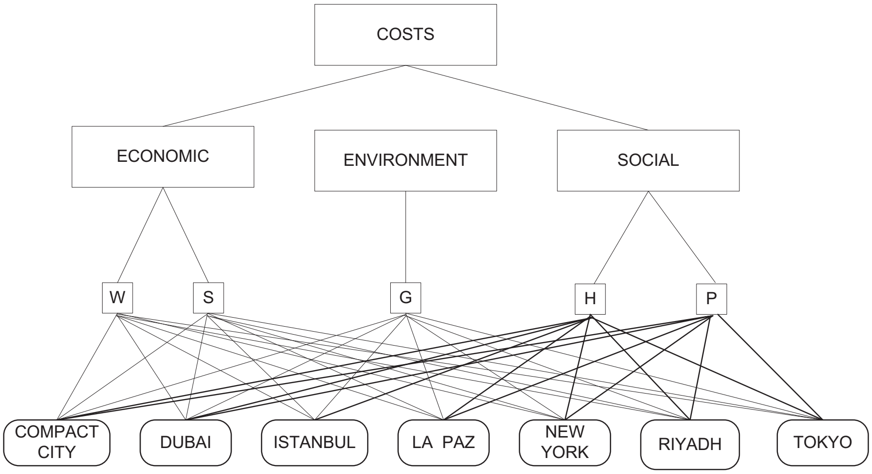


Fig. 6. The best city costs hierarchy.

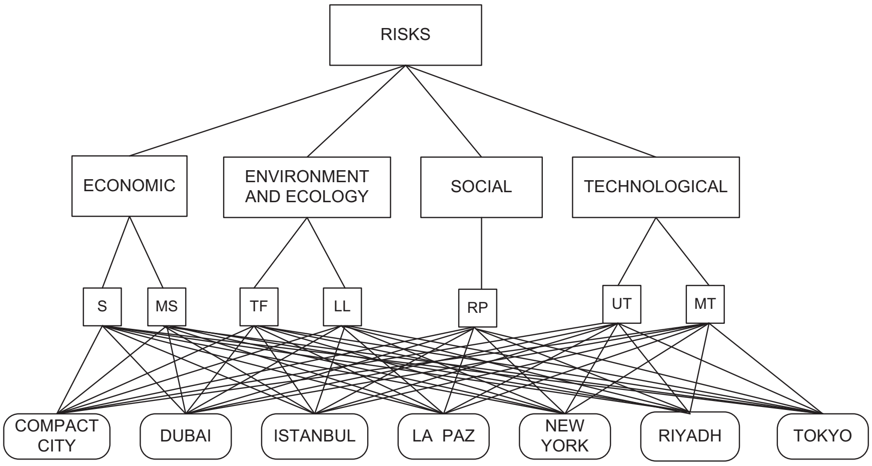


Fig. 7. The best city risks hierarchy.

Table 2
Criteria under Opportunities.

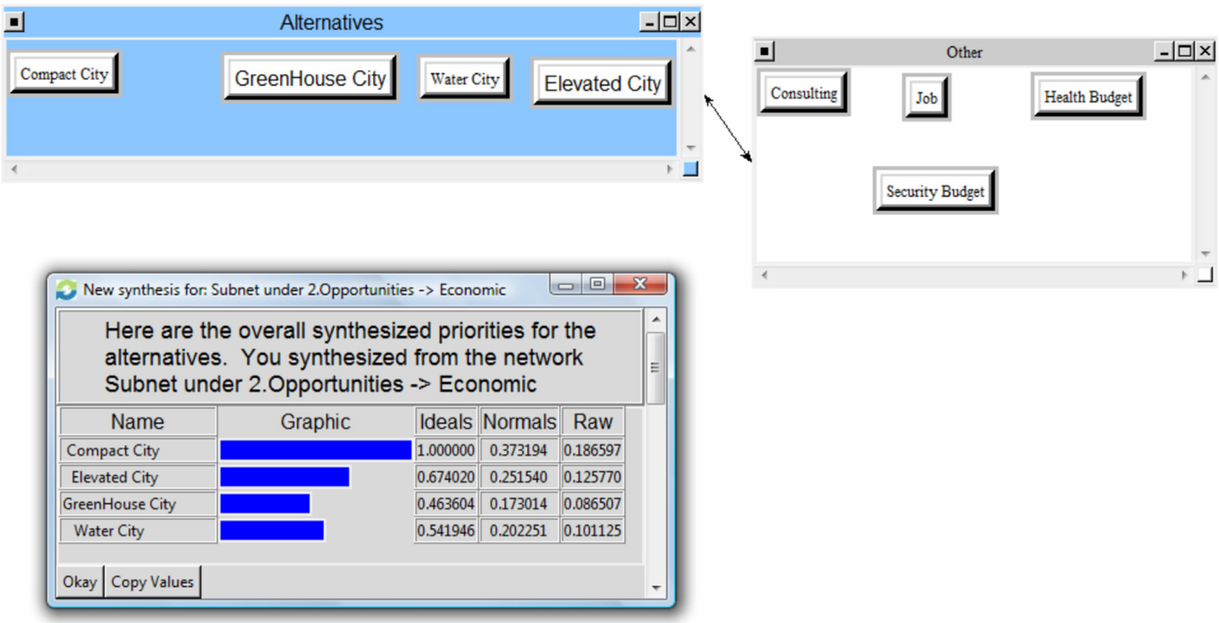
Opportunities	
Label	Criteria
Economic	
I	Improving the budget
J	Job creation
E	Expandability
Social	
L	Leisure time
Technological	
T	Better technological advances
I	Measures of innovation

Table 3
Criteria under Costs.

Costs	
Label	**Criteria**
Economic	
W	Waste disposal
S	Security cost
Social	
H	Heritage cost
P	Psychological cost due to traffic, air pollution and complexity
Environmental	
G	Loosing green in favor of buildings

Table 4
Criteria under Risks.

Risks	
Label	**Criteria**
Economic	
S	Economic sustainability
MS	Risk in maintaining the public services
Environment and ecology	
TF	Threat to flora and fauna
LL	Unacceptable losses of life
Technological	
UT	Uncertainty about technological feasibility
MT	Misuse of technology
Social	
RP	Population increase



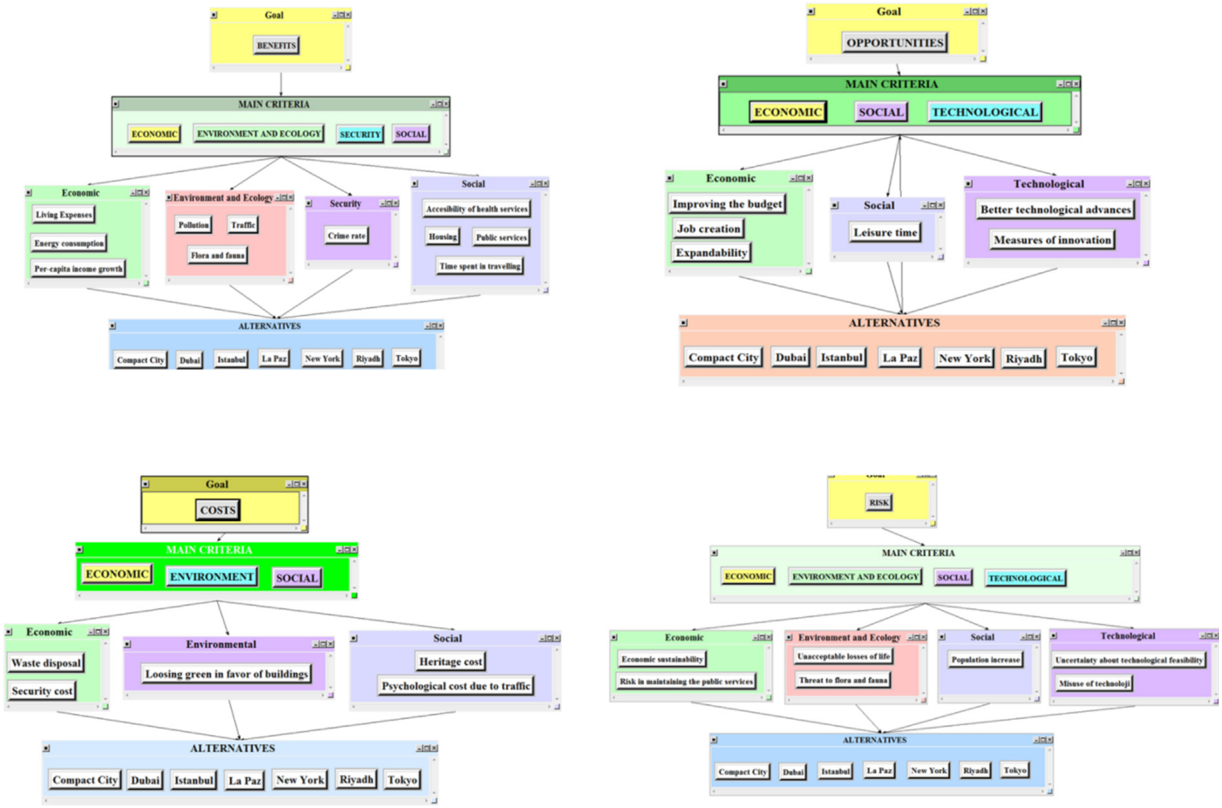


Fig. 8. The super decision models of the problem.

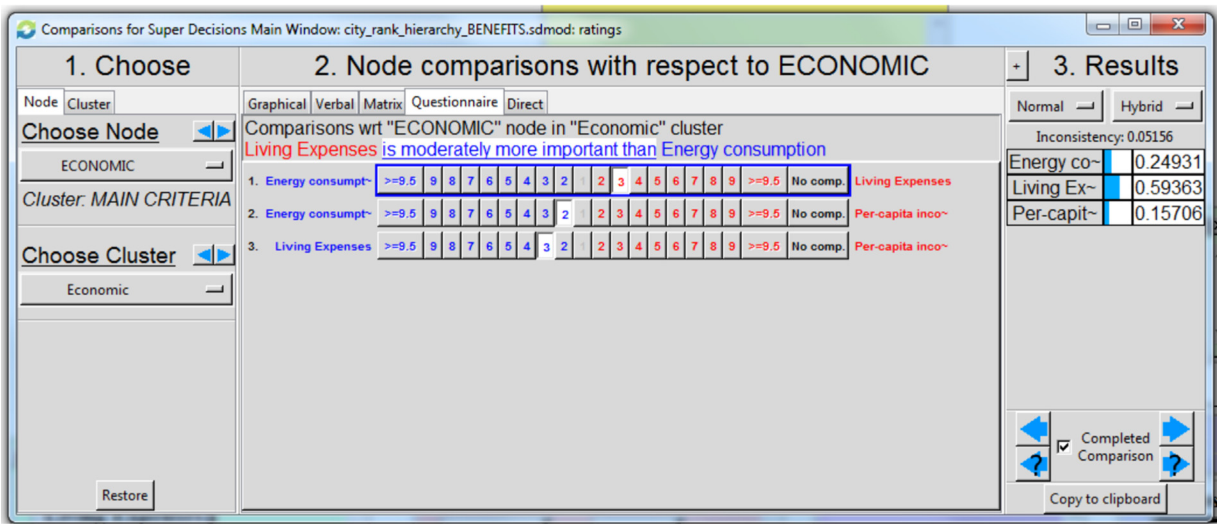


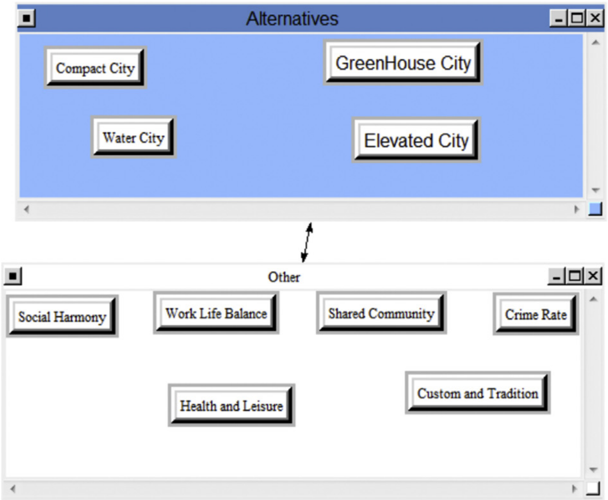
Fig. 9. An example screen view for paired comparisons.

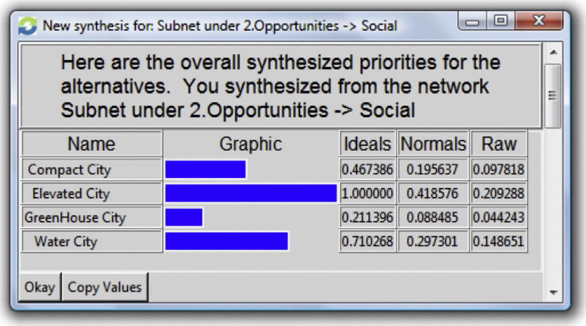
1.7. Opportunities – social subnet and synthesis

The social opportunities offered by the future cities have been measured in terms of social harmony, work-life balance, reduced crime rate and opportunities for leisure time. The figure below shows the subnet for social opportunities and the synthesis shows that Elevated City has the highest priority.

Table 5
Criteria priorities.

	Priority
Benefits (0.3)	
Economic (0.44)	
Living expenses (0.59)	0.077
Energy consumption (0.25)	0.033
Per-capita income growth (0.15)	0.019
Environment and ecology (0.14)	
Pollution (0.33)	0.0138
Traffic (0.52)	0.021
Flora and fauna (0.14)	0.0058
Security (0.29)	
Crime rate (1)	0.087
Social (0.13)	
Housing (0.16)	0.006
Accessibility of health services (0.23)	0.009
Public services (0.175)	0.007
Time spent in travelling (0.43)	0.016
Opportunities (0.23)	
Economic (0.43)	
Improving the budget (0.32)	0.031
Job creation (0.49)	0.048
Expandability (0.19)	0.019
Social (0.15)	
Leisure time	0.036
Technological (0.42)	
Better technological advances (0.67)	0.064
Measures of innovation (0.33)	0.032
Costs (0.27)	
Economic (0.5)	
Waste disposal (0.33)	0.044
Security cost (0.66)	0.089
Social (0.25)	
Heritage cost (0.5)	0.033
Psychological cost (0.5)	0.033
Environment (0.25)	
Loosing green (1)	0.067
Risks (0.20)	
Economic (0.45)	
Economic sustainability (0.75)	0.068
Risk in maintaining the public services (0.25)	0.022
Environment and ecology (0.14)	
Threat to flora and fauna (0.25)	0.007
Unacceptable losses of life (0.75)	0.021
Social (0.13)	
Population increase (1)	0.026
Technological (0.28)	
Uncertainty about technological feasibilities (0.33)	0.018
Misuse of technology (0.67)	0.038




New synthesis for: Subnet under 2.Opportunities -> Social

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Subnet under 2.Opportunities -> Social

Name	Graphic	Ideals	Normals	Raw
Compact City		0.467386	0.195637	0.097818
Elevated City		1.000000	0.418576	0.209288
GreenHouse City		0.211396	0.088485	0.044243
Water City		0.710268	0.297301	0.148651

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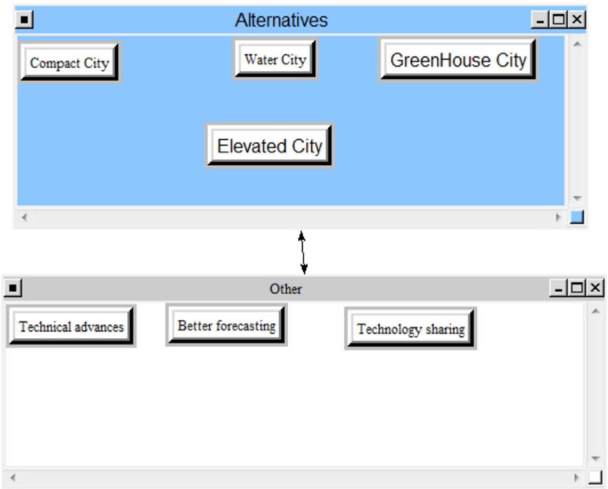
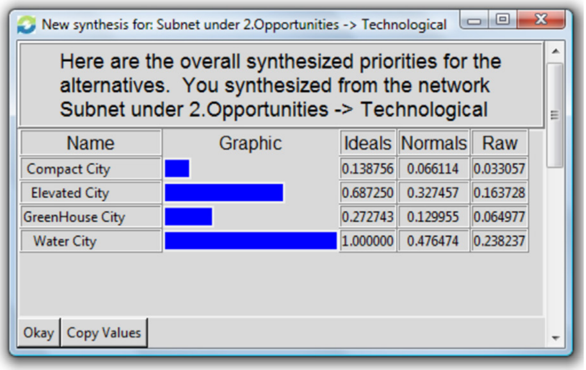
1.8. *Opportunities – technological subnet and synthesis*

The technological opportunities offered by the future cities have been measured on parameters such as better technical advances in terms of technology sharing for improving the overall aspects of life. The figure below shows the technological subnet and synthesis of the subnet shows that Water City has the highest priority.




New synthesis for: Subnet under 2.Opportunities -> Technological

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Subnet under 2.Opportunities -> Technological

Name	Graphic	Ideals	Normals	Raw
Compact City		0.138756	0.066114	0.033057
Elevated City		0.687250	0.327457	0.163728
GreenHouse City		0.272743	0.129955	0.064977
Water City		1.000000	0.476474	0.238237

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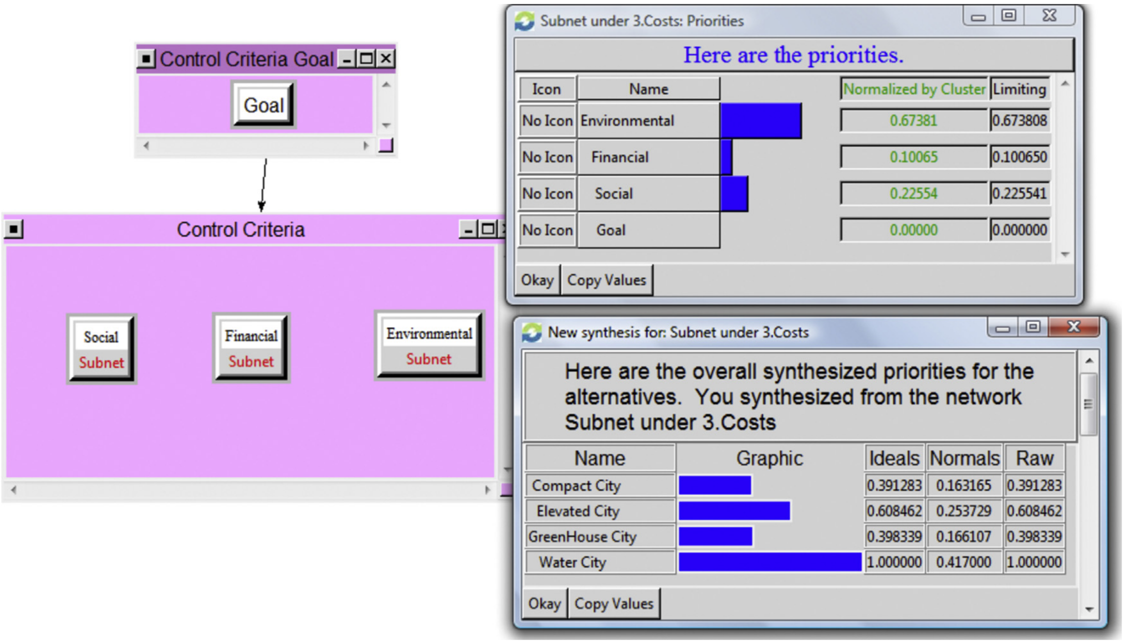
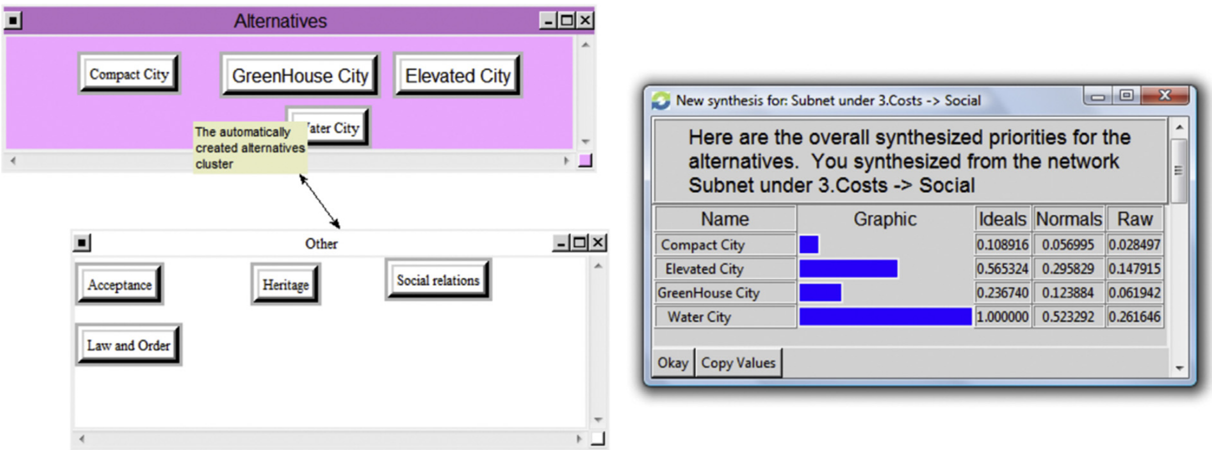
2. Costs

Under the costs subnet, there are social, financial and environmental costs as the control criteria for judging the costs for the alternative cities. The figure below shows the costs control criteria and the priorities of the control criterion. It also shows the priorities of the alternatives under the costs merit.



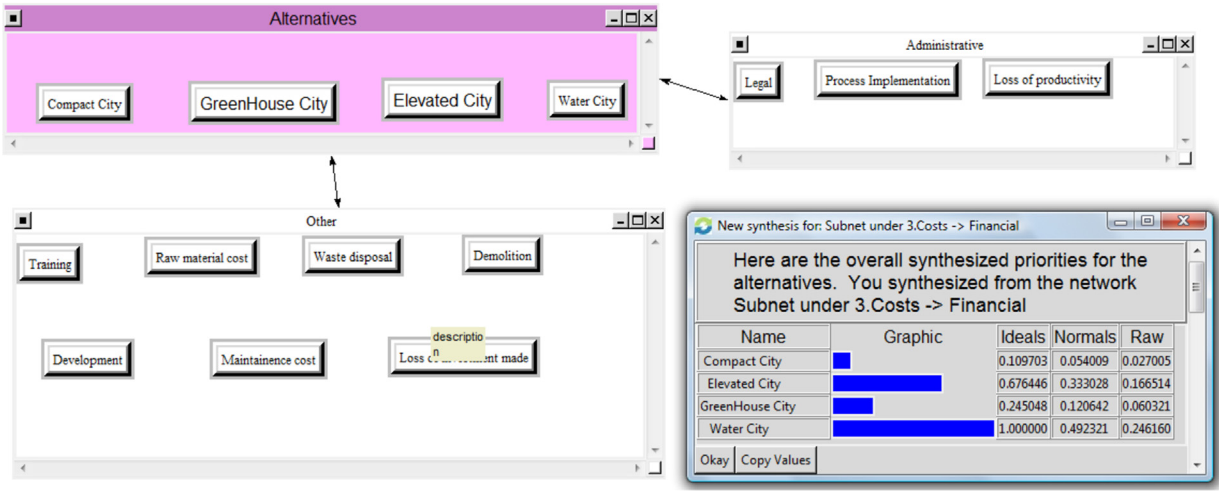
2.1. Costs – social subnet and synthesis

The social costs for the future cities have been measured in terms of heritage loss, acceptance cost (cost paid by individuals for accepting the best alternative) and also the cost of maintaining law and order. The figure below shows the social subnet and synthesis shows that the Water City has the highest cost.



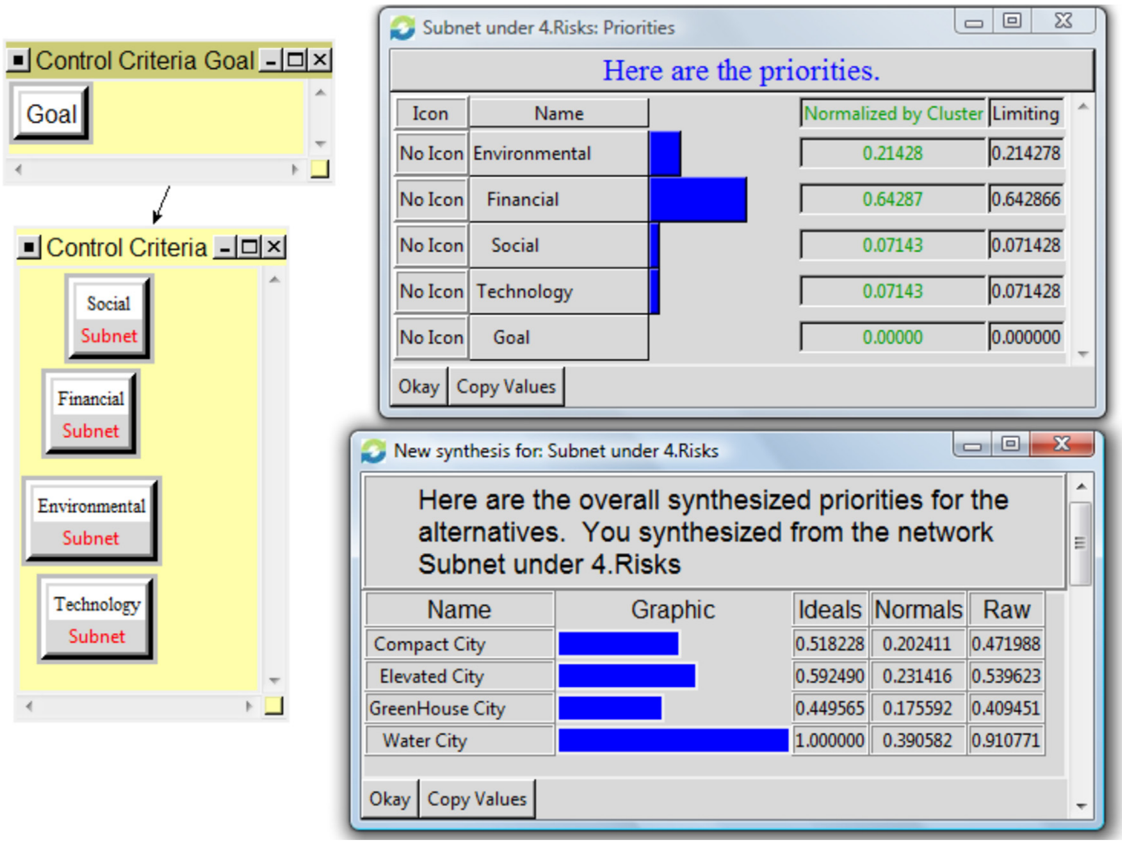
2.2. Costs – financial subnet and synthesis

The financial costs for the future cities have been measured in terms of development and maintenance cost for any such city, waste disposal problem, raw material cost, loss in investment made presently and the complexity of the process. The figure below shows the financial subnet and the synthesis shows that Water City has the maximum cost.



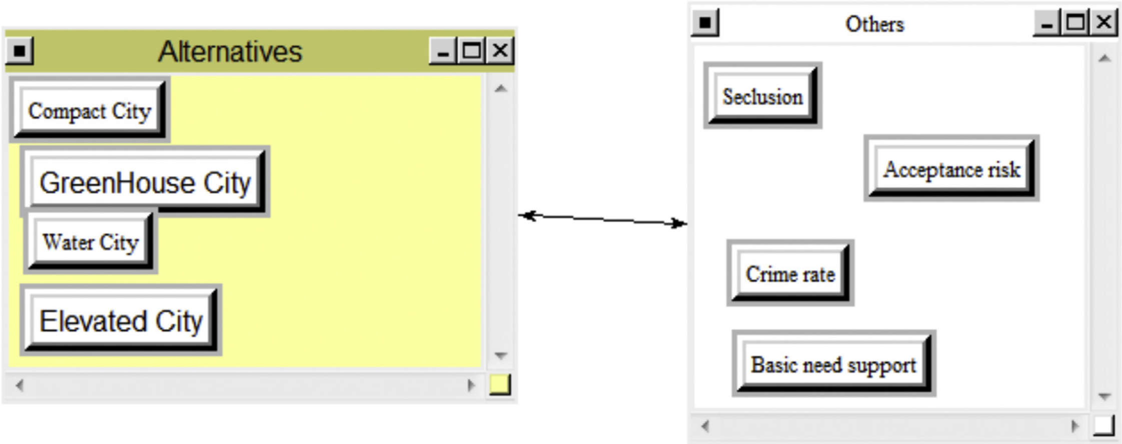
3. Risks

Under the Risks subnet, there are financial, environmental, technological and social risks as control criteria for judging the risks posed by the alternative cities. The figure below shows the risks control criteria and the priorities of the control criteria. It also shows the priorities of the alternatives under the Risks merit.



3.1. Risks – social subnet and synthesis

The social risks for the future cities have been measured in terms of crime rate, seclusion from the near and dear ones and basic support from the society. The figure below shows the social subnet and the synthesis shows that Elevated City has the highest social risk.



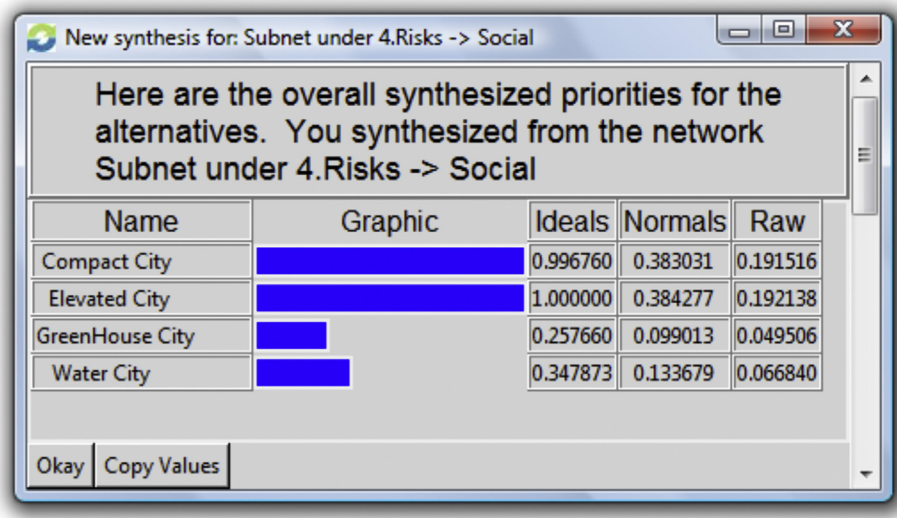
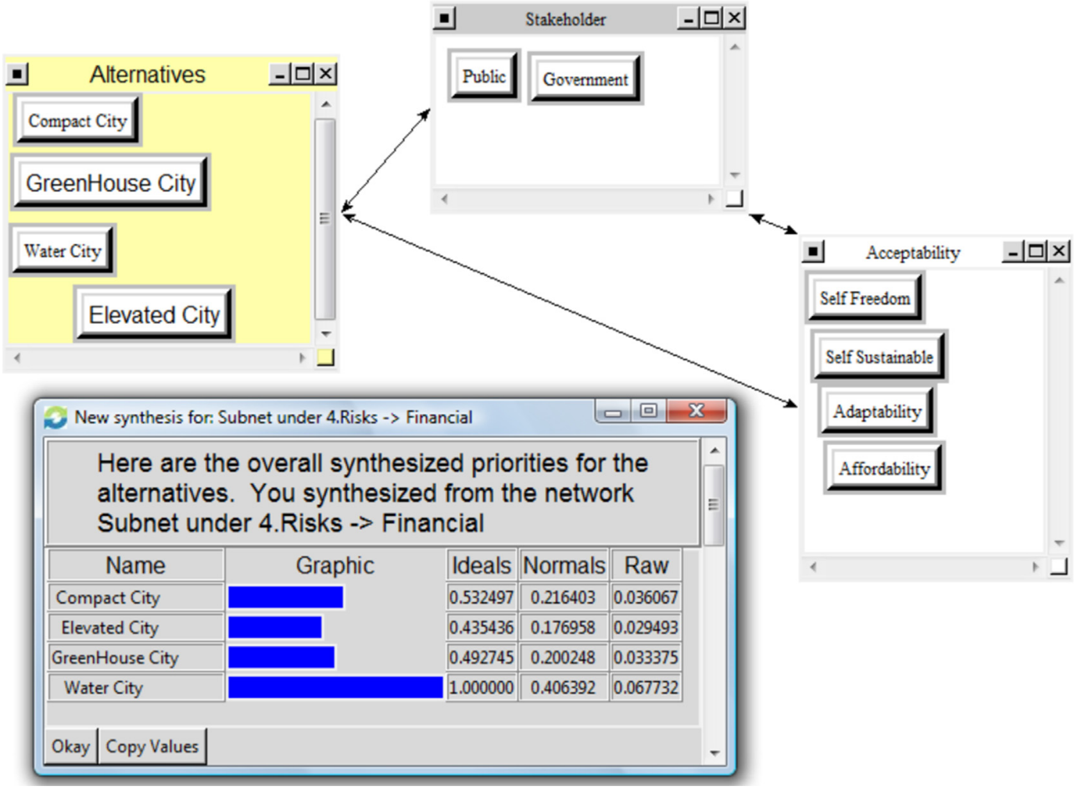


Table 6
Overall outcome.

	Benefits (0.30)	**Opportunities** (0.23)	**Costs** (0.27)	**Risks** (0.20)	**Overall Outcome** Long term (additive) bB + oO-cC-rR	Short term (multiplicative) BO/CR
Compact City	1.00	1.00	1.00	0.54	1	1
Dubai	0.5	0.40	0.48	0.53	0.014	0.42
Istanbul	0.53	0.53	0.61	0.65	−0.11	0.38
La Paz	0.43	0.29	0.38	0.37	0.11	0.48
New York	0.79	0.66	0.90	1.00	−0.37	0.32
Riyadh	0.53	0.29	0.39	0.63	−0.07	0.33
Tokyo	0.82	0.73	0.81	0.99	−0.06	0.40

3.2. Risks – financial subnet and synthesis

The financial risks for the future cities have been measured in terms of sustainability, adaptability and affordability. Moreover, there may be financial risks in maintaining the public services. The figure below show the subnet for financial risks and the synthesis results shows that Water City has the highest financial risk.



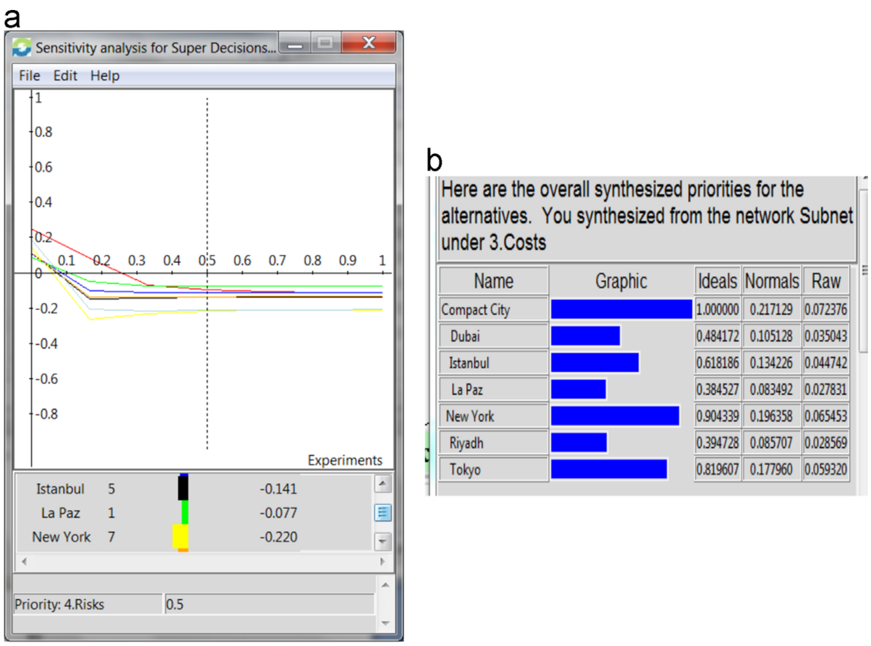
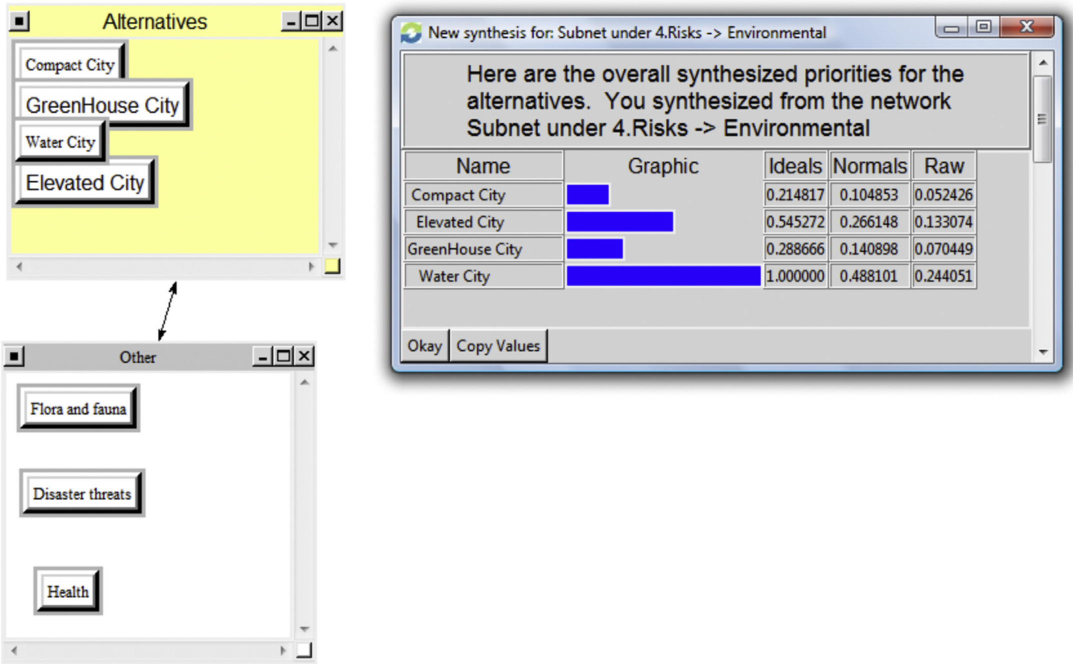


Fig. 10. (a) Sensitivity analysis (Risks) and (b) overall synthesis under Costs.

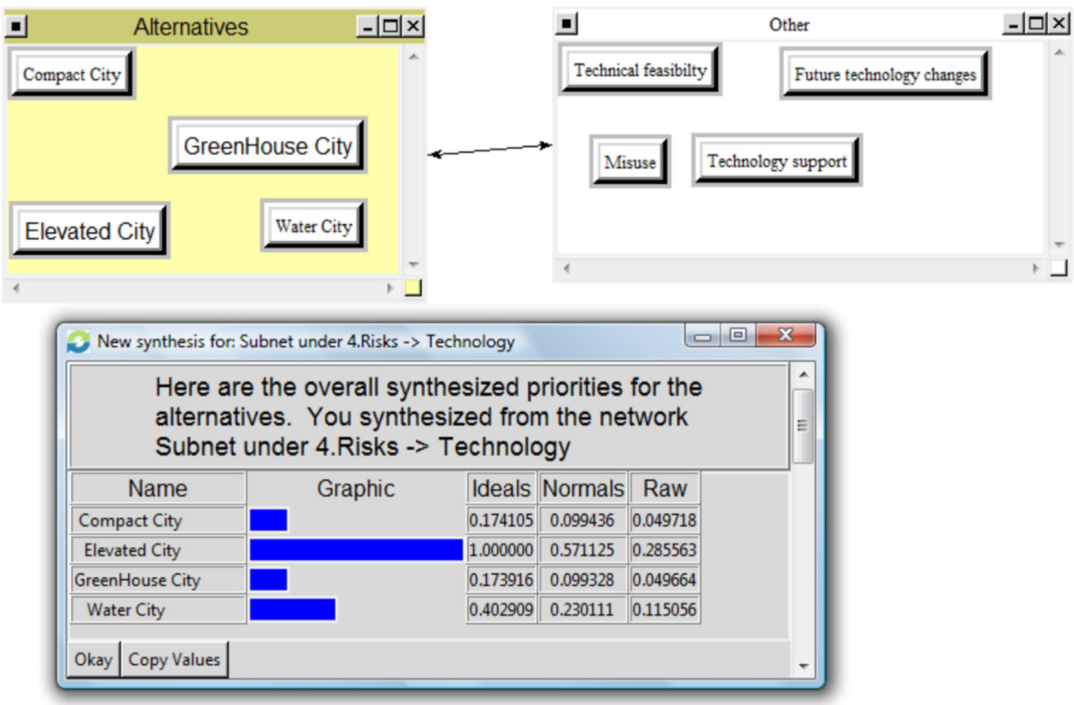
3.3. Risks – environmental subnet and synthesis

The environmental risks have been measured in terms of threat to flora and fauna, huge losses of life and property from natural calamities and the unknown risk to human health. The figure below shows the subnet and the synthesis result shows that the Water City has the highest environmental risk.



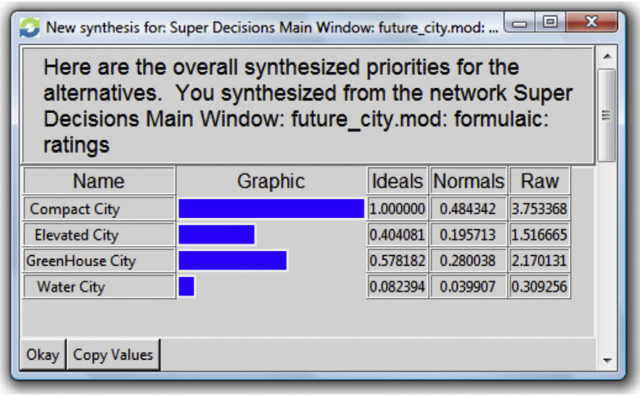
3.4. Risks – technological subnet and synthesis

The technological risks have been measured in terms of uncertainty about technological feasibility, misuse of technology, risk of reaching a dead-end in technology and increase in energy for the increasing population. The figure below shows the subnet for technological risks and the synthesis result shows that Elevated City has the highest risk.



3.5. Multiplicative result

The synthesized priorities of BOCR merits are used in this method. This is good for short-term solution. The below figure shows the result of multiplicative method and shows that Compact City should be the preferred alternative for future city.



New synthesis for: Super Decisions Main Window: future_city.mod: ...

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Super Decisions Main Window: future_city.mod: formulaic: ratings

Name	Graphic	Ideals	Normals	Raw
Compact City		1.000000	0.484342	3.753368
Elevated City		0.404081	0.195713	1.516665
GreenHouse City		0.578182	0.280038	2.170131
Water City		0.082394	0.039907	0.309256

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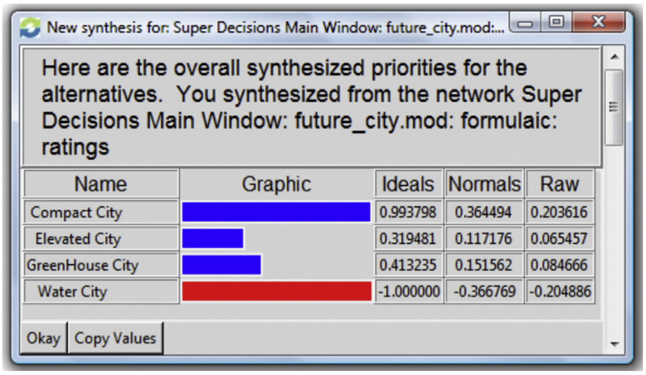
3.6. Additive result

The additive method uses the BOCR priorities of BOCR merits along with the weightage of benefits, opportunities, costs and risks, which are obtained by rating of the best alternative of each merit with respect to the strategic criteria. The figure below shows the additive results and shows that Compact City should be the preferred alternative for future cities.



New synthesis for: Super Decisions Main Window: future_city.mod:...

Here are the overall synthesized priorities for the alternatives. You synthesized from the network Super Decisions Main Window: future_city.mod: formulaic: ratings

Name	Graphic	Ideals	Normals	Raw
Compact City		0.993798	0.364494	0.203616
Elevated City		0.319481	0.117176	0.065457
GreenHouse City		0.413235	0.151562	0.084666
Water City		-1.000000	-0.366769	-0.204886

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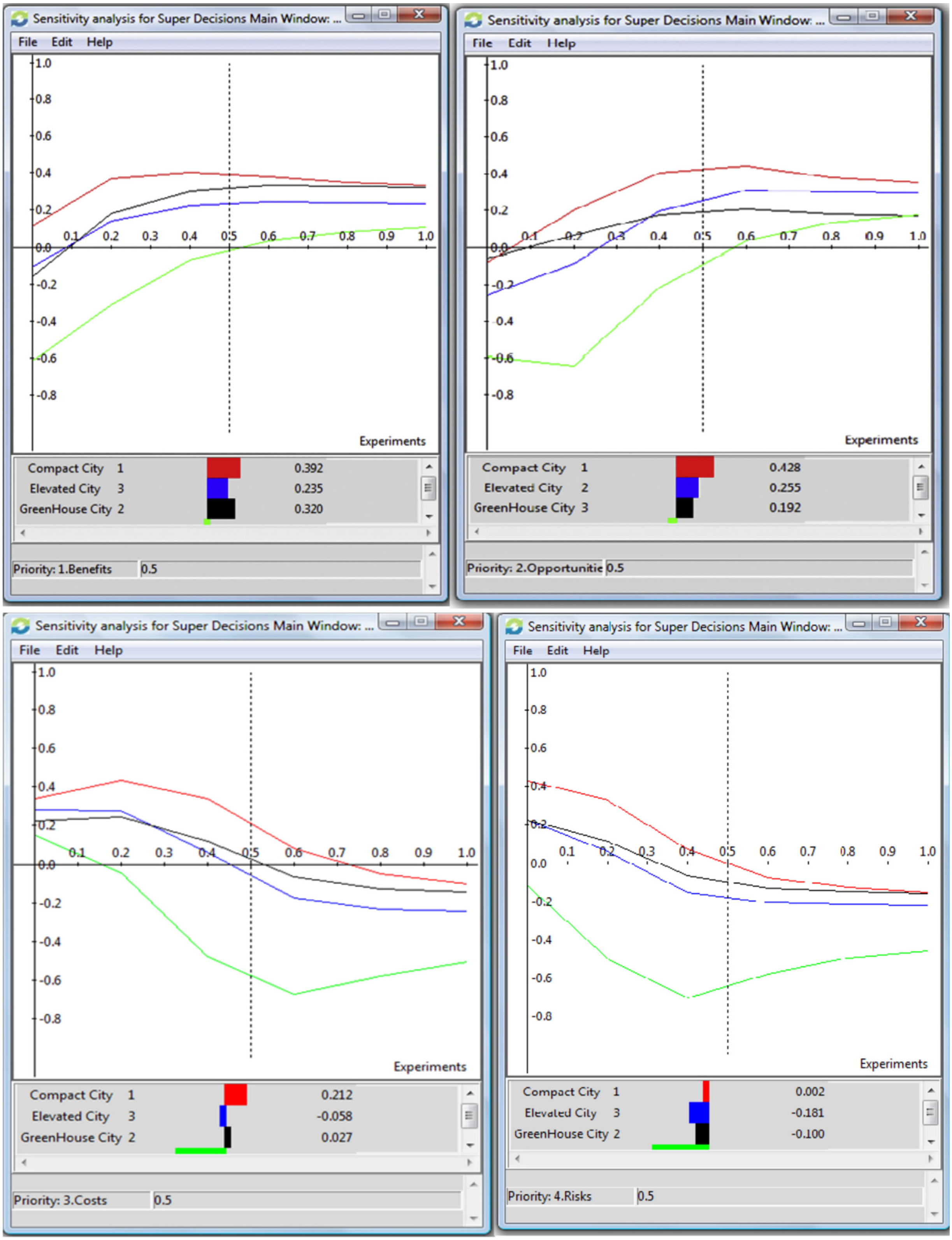
3.7. Sensitivity analysis

Sensitivity analysis is done to gauge the variance in the overall result due to changes in a particular input parameter. We have done sensitivity analysis with respect to the weightage of the benefits, opportunities, costs and risks as shown in the figures below. Sensitivity analysis shows that Compact City should be the best alternative though there has been variation for second preferred alternative.


Sensitivity analysis for Super Decisions Main Window: ...
File Edit Help
Experiments
Compact City 1 0.392
Elevated City 3 0.235
GreenHouse City 2 0.320
Priority: 1.Benefits 0.5
Sensitivity analysis for Super Decisions Main Window: ...
File Edit Help
Experiments
Compact City 1 0.428
Elevated City 2 0.255
GreenHouse City 3 0.192
Priority: 2.Opportunitie 0.5
Sensitivity analysis for Super Decisions Main Window: ...
File Edit Help
Experiments
Compact City 1 0.212
Elevated City 3 -0.058
GreenHouse City 2 0.027
Priority: 3.Costs 0.5
Sensitivity analysis for Super Decisions Main Window: ...
File Edit Help
Experiments
Compact City 1 0.002
Elevated City 3 -0.181
GreenHouse City 2 -0.100
Priority: 4.Risks 0.5

4. A second model

The vision of what future cities will look like is based on emerging technology that is available now. This modern technology will have to be refined and downsized in many cases for production quality. One can look for nanotechnology to have taken over in many fields.

In today's world, we have topographically different kinds of cities; three dimensional sky scraper cities like Manhattan, flat cities like Los Angeles, connected hill cities like Rome, water cities like Dubai, cold weather cities as in Siberia, cities that combine two continents like Istanbul which straddles two continents across the Bosphorus, mountain cities like La Paz, the highest city in the world (nearly 2 miles high), desert cities like Riyadh, underground cities like downtown Toronto's underground walkway PATH linking 28 km of, services and entertainment, and Moon and Mars cities like fully enclosed compact city. Fig. 1, shows pictures of some of the metropolitan cities in this world and also perhaps the next.

4.1. Criteria for the process of designing and selecting a desired city – an AHP application with choices having a long range view in mind

Here we select some of the cities known in the world, with each having some characteristics that make it noticeably different. There are numerous cities with millions of people, surrounded by metropolitan areas with complex structures and highly modern services and technologies. We have chosen seven of them. Here is our city list with the specific reasons that they are chosen as alternatives: Dubai as a city on the water, Istanbul as the only city which connects two continents, La Paz for being one of the highest location cities, New York for its three dimensions, Riyadh as a city in the desert, Tokyo as one of the largest and most widely spread cities and finally Compact City.

We structured our model to choose the best city in four parts: Benefits, Opportunities, Costs and Risks (BOCR). Benefits and Costs apply to the present while Opportunities and Risks apply to the future. The criteria we identified include those used in the published literature related to city ranking (*Cities Ranked and Rated* by Sperling and Sander, 2007). While those authors used only criteria that are tangible, we have included in addition intangible ones that we measure in working out the exercise. Fig. 2 shows the main structure of the model with B, O, C R and the outcome of the strategic analysis in Fig. 3.

Fig. 4 below represents the structure of the Benefits model. At the second level of the hierarchy are the criteria that we chose to judge the cities and at the third level are the candidate cities, the alternatives of the decision making process. To save space we abbreviate the criteria and listed them in full in Table 1. Similarly Figs. 5–7 show the Opportunities, Costs and Risks structures respectively and Tables 2, 3 and 4 list the corresponding criteria.

Fig. 8 shows the Benefits, Opportunities, Costs and Risks model views from the Super Decisions Software. We have to determine the priorities of the criteria and then judge the seven cities by comparing them on each criterion separately and finally weigh or multiply the priorities of the alternatives by the importance or priorities of the criteria and add to determine the best city. We call these judgments a system of comparisons or better, pairwise comparisons.

Fig. 9 gives a paired comparison screen in the Benefits model with respect to the Economic criterion, as an example.

According to Fig. 9, Living Expenses are three times more important than Energy Consumption and on the other hand, Per-capita Income is two times more important than Energy Consumption. This gives us the priority vector approximately as (0.59, 0.25, 0.16) for the subcriteria (Living Expenses, Energy Consumption, Per-capita Income), shown on the right of Fig. 9. We have the inconsistency index as 0.015 for this comparison matrix, which needs to be less than 0.10 for a consistent outcome.

The pairwise comparison judgments are entered by comparing a criterion listed on the left of the table with another listed at the top. A criterion compared with itself is always assigned the value one. The numbers 3, 5, 7, and 9 correspond to the verbal judgments of the comparisons of elements on the left over those at the top: "moderately more dominant", "strongly more dominant", "very strongly more dominant", and "extremely more dominant" (with 2, 4, 6, and 8 for compromise between the previous values). Reciprocal values (1/3, 1/5, 1/7, 1/9) are automatically entered when the element on the left does not dominate but is dominated by the element at the top of the table.

The priorities are obtained by raising the matrix to a large power to capture all the interactions, adding the entries in each row and dividing by the total sum of the rows. We are permitted to use decimal values between the integers, such as 2.6, if desired. It is mathematically demonstrated that it is necessary to use this scale to get meaningful results in practice. It represents the normal range of human sensitivity to phenomena that are homogeneous. When things are widely scattered, they can be grouped into separate clusters with a common element in adjacent clusters and the scale 1–9 is applied to compare the elements in each cluster, with the common element serving as a link. When there are actual measurements for pairs being compared, such as money, we can use the ratio of their measurements.

In Table 5 we show the priorities of the criteria that have been calculated by using each model.

Table 6 gives the overall outcome of the alternatives.

As we see from Table 6, with the results given using both additive negative and multiplicative formulas, *Compact City* is the best choice in both cases. Additive formula is frequently interpreted to mean the best long term alternative while the multiplicative one is to mean the best short term alternative. In our example the ranks of the cities are the same for both methods of synthesizing although this is not necessarily true in general. La Paz is second, Dubai is the third and Tokyo comes as fourth. Though the second place finish of La Paz is perhaps surprising, we see from the above table that is least risky and also the least costly (also from Fig. 10(b)). To further explore our outcome, we can show the sensitivity analysis with respect to Risk. As we can see from Fig. 10(a), if Risks become more important in our model (after 0.35), La Paz becomes the best alternative.

References

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